VOLUME XXVII NUMBER 4 WHOLE NUMBER 223

THE JOURNAL

OF

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

EDITOR
C. A. CHANT
University of Toronto, Toronto

ASSOCIATE EDITORS

J. S. PLASKETT
Director of the Dominion Astrophysical Observatory, Victoria, B.C.

J. PATTERSON
Director of the Meteorological Service of Canada, Toronto

R. MELDRUM STEWART
Director of the Dominion Observatory, Ottawa

PUBLISHED MONTHLY
(Ten numbers per year)

April, 1933

PRINTED FOR THE SOCIETY
TORONTO: 198 COLLEGE ST.

THE JOURNAL

OF

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

Vol. XXVII, No. 4 APRIL, 1933 Whole No. 223

Articles PAGE

Testing a Tube Sensitometer - - - *W. S. Armstrong* 137
The Orbital Elements of H.D. 210334 - - *W. E. Harper* 146
The Spectra of Meteors - - - - *P. M. Millman* 150
Artificial Transmutation of the Elements - *Lord Rutherford* 155

Review of Publications
The Expanding Universe, by Sir Arthur Eddington - *(C.A.C.)*;
Amateur Telescope Making, ed. by A. G. Ingalls - *(C.A.C.)* 163

Notes and Queries
A Bright Meteor in Daylight—The Pleiades Riding over a Hill —A Thirty-inch Steel Reflector—Behaviour of Bees at the Eclipse of the Sun - - - - - - *C.A.C.* 165

Meetings of the Society
At Vancouver—Montreal—Winnipeg—London—Toronto - - 168

Upon request, made previous to publication of article, contributors will be supplied free either with fifty copies of the issue containing the article, or with the sheets containing the article attached to a printed cover. If separate reprints are desired the cost will be as follows:

	4 pp.	8 pp.	12 pp.	16 pp.	20 pp.	24 pp.
50 copies	$3 50	$5 50	$ 9 50	$10 00	$13 00	$16 00
100 copies	4 00	7 00	10 00	11 00	14 00	18 00
200 copies	4 50	8 00	11 00	12 00	15 50	20 00

Covers, extra, 50 copies, $1.50; 100 copies, $2.00; 200 copies, $2.50.

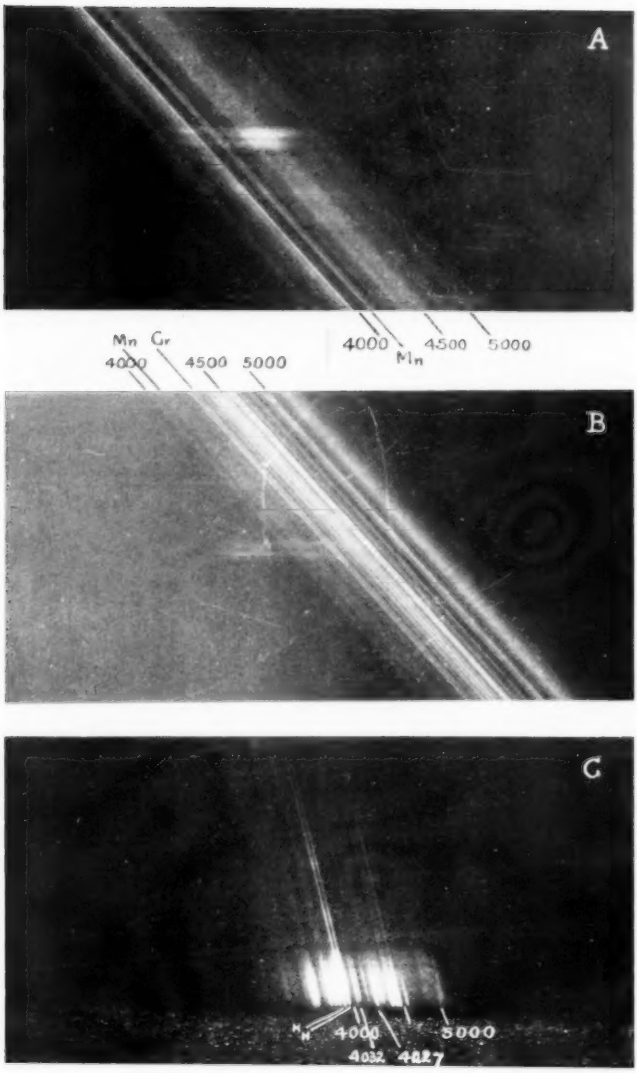
Business correspondence, remittances, etc., should be addresed to J. H. Horning, Treasurer of the Society, 198 College Street, Toronto.

Communications regarding Library matters should be addressed to the Librarian.

$2.00 per annum. Single numbers, 25 cents.

Subscription to the JOURNAL is included in membership fee.

PLATE II



SPECTRA OF METEORITES

For description, see bottom of page 154.

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY
OF CANADA

Vol. XXVII, No. 4 APRIL, 1933 Whole No. 223

TESTING A TUBE SENSITOMETER

By W. S. Armstrong

IN photographic photometry one of the chief difficulties is to obtain the intensities of the sources producing images of different densities on the photographic plate. In stellar photometry many methods are used to provide a scale of intensities; for example: the method of the tube sensitometer, devised by Parkhurst and Jordan[1]; the method of extra-focal exposures at different distances from the focus, devised by E. S. King[2]; the grating methods of Kapetyn-Wirtz[3], or Schwartzchild[4]; and others[5]. Of these the only one which uses an absolute method, *i.e.*, a laboratory method, of determining the scale is that of Parkhurst and Jordan.

In their method Parkhurst and Jordan illuminated simultaneously certain areas of a photographic plate by lights differing in intensity by a known ratio. They obtained this illumination by using a sensitometer box containing a series of light-tight cells. One end of this box was covered by a metal plate in which there was a circular opening opposite the centre of each cell. These openings were graded in size. When they were uniformly illuminated, the amount of light passing into each cell depended on the diameter of the opening in front of it. A photographic plate placed

[1]Ap. J., XXVI, 244.
[2]H.A., 59, S 33, 95, 127, 129, 157.
[3]A.N., 154, S 317.
[4]A.N., 183, S 297.
[5]Handbuch der Astrophysik, Vol. II, Chap. 5 (d).

at the other end of the cells was blackened in squares corresponding to the cells. The opacity of the images depended on the amount of light admitted to the cells. By this means they obtained a scale of darkening on the plate corresponding to the differences in intensity caused by the different-sized openings. By measuring the opacities of the extra-focal images of stars on the plate, they obtained from this scale the ratios of the intensities and hence the differences in magnitudes of these stars. This method eliminated the use of the "reciprocity law" of exposure by equalizing the times of exposure of the plate to the stars and to the sensitometer.

In this method it was assumed that the intensity of the light acting on the photographic plate in any cell was directly proportional to the area of the opening in that cell. Dr. R. K. Young found in two sensitometers of this type that some of the openings gave a consistent deviation from the characteristic curve, which is obtained by plotting the densities of the images against the logarithms of the exposures which produced them. In these instruments the openings were made in two plates, in one of which they were graded in size while in the other they were all of the same size. The openings in the two plates were similarly arranged so that they were in line with one another when the plates were fitted into a suitable frame. It was thought that the systematic deviations from the characteristic curve of the densities of images produced by certain openings was due to two causes:

(1) The openings might not have been accurately centred with respect to each other in the two plates. This would decrease the amount of light reaching the photographic plate from these openings.

(2) Internal reflections might have taken place inside the instrument, and, owing to the fact that no diaphragms were used in the cells, this internally reflected light might have reached the photographic plate. Lack of centering might also have permitted internally reflected light to reach the plate. Dr. Young constructed the sensitometer described hereafter with a view to eliminating these sources of error. The purpose of this research was to find whether these errors had been eliminated in this instrument and whether any constant sources of error remained.

This instrument was tested by comparing the characteristic

curve obtained by using the areas of the sensitometer openings as measures of intensity with the characteristic curve obtained from the same plate using the inverse square law of distances to determine the relative intensities. This method depends entirely on measures made in the laboratory and hence is an absolute method. The accuracy of this method depends only on the accuracy of the photometric measurements, since measures of distance can be made with much greater precision than is possible in measures of density on ordinary photographic plates. In the ordinary method of using standard star magnitudes to give the intensity scale the accuracy depends not only on the accuracy of the photometric measurements but also on that of the standard star magnitudes. Their accuracy is of the order of a few hundredths of a magnitude or about four or five per cent. Laboratory methods give much greater accuracy in the determination of relative intensity.

The Apparatus

The latest sensitometer constructed by Dr. Young has fourteen cells arranged so that their centres lie at equal intervals on the perimeter of a rectangle 3 inches by 1.2 inches. Each cell consists of a brass tube 2.30 inches long and 0.484 inches inside diameter with bakelite diaphragms at each end. Two other diaphragms are placed between them in such positions that they prevent internal reflections from the sides of the tube from reaching the photographic plate. The inside wall of the tube is blackened to reduce these reflections. All diaphragms were cut and drilled at one setting of the lathe so that the openings were concentric within 0.001 of an inch when the diaphragms were placed in the tube. They were made to fit tightly into the tube and the end diaphragms were pressed in to the level of the ends of the tube. The openings in the diaphragms at the plate end of the tubes are all ⅛-inch in diameter and those at the source end are graded from 0.044 inches to 0.265 inches in diameter. Two bakelite plates, into which the ends of the tubes are fitted so that they are level with their surfaces, hold the tubes in position parallel to each other. The plates are rigidly fastened together to make a strong frame which holds the tubes in proper alignment. The tubes are not arranged in a regular

order according to the size of the openings, but are purposely staggered in order that a systematic error in the photographic plate will not appear as a systematic error in the characteristic curve[1]. This part of the apparatus fits inside an oak box with a removable back and a sheet of opal glass over the front at a distance of one inch from the source end of the tubes. When tested, the opal glass was found to be an almost perfect diffuser so that it will illuminate the sensitometer openings uniformly. The box is constructed so that the back is light-tight and presses the photographic plate closely against the ends of the sensitometer tubes.

The apparatus to obtain the intensity scale by the inverse square law consists of a source of light fixed in position and a plate holder which can be placed at definite known distances from it. To secure a source of sufficient and constant intensity and small surface area from which direct measurements of distance could be made conveniently presented considerable difficulty. A 32 c.p. automobile bulb connected in parallel with the source of light in the photometer to a 6-volt storage battery was finally adopted. Its intensity was kept constant within about a tenth of one per cent by keeping the photometer source adjusted to a constant intensity. The bulb was placed in a box with a circular opening, half an inch in diameter and covered by a piece of opal glass, in front of it. The opal glass acted as the source of light, as it was found to be an almost perfect diffuser, providing a source of small area from which measurements of distance could be readily made. The exposure was obtained by removing for the required length of time a cardboard shutter set up in front of the source. A frame with two pins on its base which fitted into pairs of holes in the top of the bench carried the plate holder. These holes were arranged to keep the plate holder pointed directly towards the source. The plate holder was constructed so that the images produced in it were similar in size and shape to those made by the sensitometer but were placed in rows beside them, about 1/5 of an inch farther from the central axis of the plate. There were fourteen pairs of holes at distances ranging from 18.77 inches to 155.39 inches from the source, spaced so that the ratio of the intensities for every

[1]Handbuch der Astrophysik, Vol. II, page 463.

consecutive pair of positions was constant. The range of intensities given by this means was slightly greater than that provided by the sensitometer.

A photometer of the thermo-electric type, similar to the Moll Microphotometer,[1] was used to measure the densities of the images. A rheostat in the source circuit provided a means for adjusting the intensity of the source. The deflections of the galvanometer were read to tenths of a millimetre on the ground-glass scale by means of an eye-piece. A shunt-box in the galvanometer circuit increased its sensitivity by giving a wider range of readings and therefore more sensitive measures.

The Procedure

In making the observations the same kind of plates was used throughout and the same procedure was followed for all plates in order that the measures might be comparable with one another. 4 × 5 Eastman 40 plates were used. The steps of the procedure for each plate were as follows:

1. Exposure of the plate in the sensitometer.
2. Exposure of the plate at different distances from the constant source.
3. Development and fixation of the plate.
4. Measurement of the densities of the images on the plate.

The procedure in these steps is outlined below:

1. The plate was exposed in the sensitometer by putting it in position in the sensitometer and placing the sensitometer on its back on the table directly under one of the lighting fixtures of the laboratory. The exposure was made by switching on the light for the required length of time which was measured on a stop-watch. This method of making the exposure was chosen because the intensity was sufficiently constant and because it was convenient.

2. The plate was removed from the sensitometer and placed in the plate holder for exposures at different distances. The exposures in this step were of the same length as that in the sensitometer, and were measured by the same means.

[1] Proc. Phys. Soc. of London, Vol. XXXIII, Part IV.

3. The plate was developed in Elon-Hydrochinon developer made up according to formula D-61A recommended by the manufacturers for use with Eastman 40 plates. The temperature was maintained within $\pm 0.2°C$ of a constant value of 18.3°C. The strength of the developer was made the same for all the plates by making fresh solution for each plate from a concentrated stock solution. During development, which lasted eight minutes, the developing tray was rocked steadily. After washing in cold water, the plate was fixed in a meta-bisulphide hypo for 10 minutes and then thoroughly washed and dried slowly on its edge.

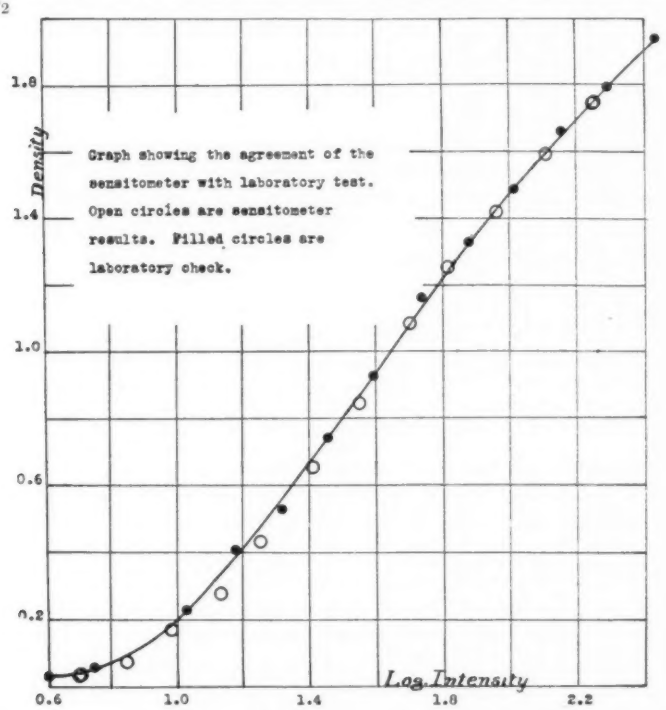
4. The final step was the measurement of the densities of the images with the photometer. Measures were made on the central part of the image. The density of the background of the plate was measured midway between the images. The light source in the photometer was maintained at a constant intensity by noting at regular intervals the deflection of the galvanometer without the photographic plate and adjusting the deflection to the original value by means of the rheostat in the source circuit. By this means changes in the density of the background of the plate were noted at the same time as the densities of the images were measured.

Reduction of Measures

Since the darkening, or characteristic curve for a photographic plate is obtained by plotting the densities of a series of photographic images of different densities against the logarithms of the exposures which produced them, the reduction of the measures is the finding of the densities of the images obtained from the different exposures. Using the notation and method of Hurter and Drifield[1], the density of an image is defined as the ordinary logarithm of its opacity. The opacity is the ratio of the intensity of the light incident on the image to that which is transmitted through it. Assuming that the thermopile voltages are proportional to the energies falling upon it and therefore to the intensities of the light transmitted through the photographic plate, and that the galvanometer deflections are proportional to the voltage applied to it, we may take the galvanometer deflections to be directly proportional to the intensities of

[1]Jour. Soc. Chem. Ind., 9, 455.

the transmitted light. Letting D_1 be the deflection of the galvanometer produced by the light incident on an image, and D_2 that produced by the light transmitted through the image, then opacity $= \frac{D_1}{D_2}$ and density = log opacity = log D_1 − log D_2. The value



of D_1 is obtained by taking the mean of the deflections for the background of the plate on the opposite sides of the image. Since all the exposure times are the same, the exposures are directly proportional to the intensities of the light falling on the photographic plate. For the images obtained at different distances from the constant source the intensities are inversely proportional to the squares of the distances from the source. To compare the intensity scale of the sensitometer with that given by the inverse square

law, the areas of the sensitometer were taken as measures of intensity.

The comparison of these two intensity scales was made by plotting the densities of the images as ordinates and the log intensities, obtained by the methods described, as abscissae. The two curves were found to be very similar in shape and they could be made nearly coincident by shifting one of them horizontally or vertically. A shift of this kind is equivalent to changing the intensity of the source which, if the change is not great, will not alter the shape of the characteristic curve. By shifting the sensitometer curves horizontally until the sensitometer and distance curves were coincident for a fixed point on the latter, the deviations of the points on the sensitometer curves from the corresponding distance curves were readily obtained.

The accompanying diagram shows one of these curves, the points obtained from measures on images formed at different distances being indicated by closed circles; those obtained from measures on sensitometer images are indicated by open circles.

The Results

On these graphs the adjusted sensitometer points lay closely along the smooth curves drawn through the points plotted from the distance measures. By measuring the deviations of the sensitometer points from the mean distance curves, it was found that the sensitometer points lay below the distance curves for the very dense images produced by the largest openings, but that there was no consistent deviation of the sensitometer points from the curves for the other images. From these deviations the average percentage deviation of the intensity of a sensitometer source from its calculated value was found to be 3.2% or 0.013 stellar magnitudes over a range of intensity corresponding to 3.0 magnitudes. This was the range for which the characteristic curve for these plates could be used to give reliable results.

In measuring the densities of the images, the density of the background was measured at points midway between the images. From these measures it was found that the density of the background of the plate increased from the centre outwards and was a

maximum along the edges parallel to the axis about which the plate was rocked during development. It was also noted that wing-shaped areas whose density was less than that of the rest of the plate projected outwards from the dense images in the direction in which the developer flowed across the plate. From these observations we consider it advisable to use a tank method of development with a weak developing solution in order to avoid these effects.

SUMMARY

1. The intensity scale given by a tube sensitometer has been compared with that given by the inverse square law of intensities and has been found to agree with it with an average deviation of 0.013 magnitudes over a range of 3.0 magnitudes when the steepest portion of the characteristic curve is used to determine the intensities.

2. In constructing a sensitometer of this type the following precautions should be observed:

(*a*) Provision should be made to have uniform illumination of the openings in the tubes.

(*b*) The openings in all the diaphragms in the tubes must be accurately centred and aligned.

(*c*) Internal diaphragms should be placed in the tubes so that no internally reflected light can reach the photographic plate.

THE ORBITAL ELEMENTS OF H.D. 210334

By W. E. Harper

THIS star is an eclipsing variable whose light curve has been extensively studied by the German astronomers, Rügener, Schneller and Plaut. The light elements for this star, whose usual designation is AR Lacertae, are given by the last two mentioned in *Astronomische Nachrichten* Nr. 5879.

The magnitudes found for the component stars are 7.66 and 7.88, making the combined magnitude of the system $6.^{m}96$. The period is 1.983244 days and inclination of the orbit 86 degrees. They find the smaller star has a diameter 0.6 that of the larger, but its greater surface brightness of nearly three to one more than offsets its smaller radiating surface and gives its luminosity 53% of the total. Their results indicate that the large star of low intrinsic luminosity totally eclipses the smaller and more luminous one at which time there is a diminution of light of $0.^{m}$ 82. The secondary minimum of their light curve is not so well determined, but the diminution in the case of this annular eclipse is deemed to be $0.^{m}$ 20.

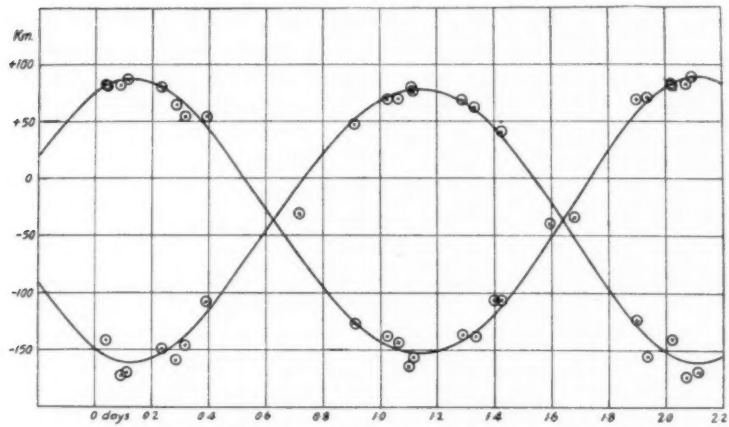
From the light curve relative dimensions only can be arrived at; it requires spectroscopic observations to deduce absolute values and in conjunction with the light elements to completely define the system. With this end in view 22 spectrograms were secured the past autumn with the single prism instrument attached to the 72-inch reflector. Of these 14 were made with the usual IM camera, the remaining eight with one of somewhat lower dispersion, IS.

The spectrum is listed in the H.D. catalogue as G5. Schneller and Plaut consider that if this has reference to the brighter component then owing to the difference in radiating power of the two components the other spectrum should be about K5. If, on the other hand, the G5 designation refers to the mean spectrum of both components, then they ought to be rated separately as G0, K0.

The actual spectra, however, as shown by our plates, are not markedly different. The one which I would call the primary, has a

spectrum about G5, the other about G2. They may be even closer in type. The G5 spectrum has, on the whole, sharper lines than the G2. Its hydrogen lines being stronger than the G2 would suggest an "earlier" subdivision, yet such a characteristic might be more properly regarded as indicative of its higher luminosity.

From the fact that the period is so close to the even 2 days the phases shift along the curve slowly, and it was only when the star had got to the west that spectra could be obtained at the times of eclipse. It was planned to observe at the exact moments of primary



Radial Velocity Curves of H.D. 210334 Showing Individual Observations

and secondary eclipse to get each component spectrum free from any effect of the other. A chapter of ill luck, such as clouds at the wrong moment and the electric power failing when setting on the star in a clear sky, has prevented good spectra being secured at the critical phase. Three plates, however, secured near eclipse times, suggest that the above classifications for type are not far astray.

The measures for radial velocity were made with a micrometer engine, from six to nineteen lines being measured for each component. The individual lines gave quite discordant results, though nothing of a systematic nature, as a tabulation of the line residuals later

showed. Repeat measures failed to change by any appreciable amount the original measures and such lack of internal agreement may be ascribed to the blending of the two solar type spectra whose lines shift up and down the spectrum by three or four angstroms. The probable error of an average plate was for the primary ± 4.6 km./sec. and for the secondary ± 5.8 km./sec., values which are twice as high as might be expected from measurements of single spectra of the same character. Due to the high range of velocity variation, however, the corresponding probable errors of the elements of the orbit are reasonably low.

As the details of the plates and reduction will appear later in our Publications, it will suffice to state that preliminary values of the orbital elements were arrived at in the usual graphical manner and these corrected by means of a least-squares solution.

FINAL ELEMENTS

$P = 1.983244$ days (accepted)
$e = 0.041 \pm .002$
$\omega_1 = 334°.82 \pm 22°.44$
$\omega_2 = 154°.82 \pm 22°.44$
$\gamma = -36.25 \pm 0.69$ km/sec.
$K_1 = 120.02$ km/sec. ± 1.49 km/sec.
$K_2 = 119.19$ km/sec. ± 1.63 km/sec.
$T =$ J.D. $2{,}426{,}625.732 \pm 0.122$ days
$a_1 = 3{,}277{,}700$ km.
$a_2 = 3{,}255{,}400$ km.
$m_1 = 1.41 \odot$
$m_2 = 1.42 \odot$

The values of a_1, a_2, m_1 and m_2 are based upon a value for i of 86° as found by Schneller and Plaut.

On the whole, there is reasonable agreement between the light and spectroscopic elements. The disturbing feature is that with masses of the two components almost identical and with the types approximately similar, how can surface luminosities differ by as much as three to one, as the German astronomers found? They state the secondary minimum was poorly observed and they planned to reobserve it. For myself I plan next season to secure good

spectra during eclipse of both components and study the same in more detail. It is quite possible that with additional observations on both counts any seeming inconsistencies will be ironed out.

It may be of interest to note that a mass of 1.4 times the sun on the basis of Eddington's curve suggests an absolute magnitude of 3.4 for the brighter component corresponding to a parallax of 0."014. The absolute magnitude based upon its diameter as determined and a surface intensity corresponding to a dG5 spectrum is 3.8.

The velocity curves shown correspond to the final elements and on these graphs the individual observations are plotted.

THE SPECTRA OF METEORS

(With Plate II)

By Peter M. Millman

THE recent ascent by Prof. Piccard to formerly unattained heights above the surface of the earth recalls to our attention the many attempts that have been made to learn more about the atmospheric shell that envelopes this planet. For heights up to five miles above sea level we have a wealth of data from direct observation and from the study of cloud motions. For the range between altitudes of five and twenty miles our information is more meagre, but still a considerable amount of knowledge has been gleaned from sounding balloons and such intrepid ascents as the one referred to above. For heights greater than twenty miles we must rely on purely theoretical considerations or on information derived from observations of physical phenomena that exist at these altitudes.

There are three main classes of natural phenomena that can be studied at heights ranging from twenty to one hundred and fifty miles. These are meteors, the aurora, and the Kennelly-Heaviside layer. All three phenomena are most pronounced at heights between fifty and seventy miles.

At present we shall confine ourselves to the first of these three classes. The observations of meteors fall naturally into two groups; first, a determination of the position and form of the meteor's path, and second, an analysis of the radiation which is produced by the meteor in flight. A great many observations of the first type have been made, but the same cannot be said of the second. Because of the unexpected appearance and the very brief duration of visibility of meteors, the best visual observations of their spectra are inconclusive, and meteors may be classed as the most difficult objects for astronomical spectrophotography. Evidence of this may be found in the fact that, up to the end of 1931, only nine meteor spectrum photographs had ever been taken. These were mostly obtained by chance during the photography of stellar spectra with objective prisms. They were photographed with lenses ranging in aperture from 24 inches to 1.2 inches, but all were fast, the slowest

having a ratio, focal length to aperture, of 6.0. A fast lens giving good definition over a wide field is one of the first requisites in meteor spectrum photography.

The dates of these nine photographs are listed in Table I along with the places where they were obtained and the references to any published work concerning them. They are all bright line spectra with little or no continuous spectrum. The amount of detail in each is indicated in the final column.

TABLE I

Spectrum	I	June	18, 1897,	Arequipa, Peru,[17]	6	bright	lines
"	II	May	11, 1904,	Moscow, Russia,[18]	17	"	"
"	III	Aug.	12, 1904,	Moscow, Russia,[18]	13	"	"
"	IV	Aug.	12, 1907,	Moscow, Russia,	21	"	"
"	V	May	18, 1909,	Arequipa, Peru,[19]	53	"	"
"	VI	Aug.	10, 1920,	Mt. Wilson, Calif.,	31	"	"
"	VII	Mar.	7, 1924,	Mt. Wilson, Calif.,	28	"	"
"	VIII	Sep.	29, 1924,	Bergedorf, Germany,[20]	13	"	"
"	IX	Dec.	15, 1931,	Blue Hill, Mass.,[21]	42	"	"

These spectra have been recently studied at Harvard and have yielded some interesting results. Direct photographs of five of the above meteors were obtained and in these cases, since the scale of dispersion on the plate was known, preliminary wavelengths could be computed with the help of the direct photographs. The preliminary wavelengths were then corrected after several prominent lines had been identified. In the four cases where no direct photograph existed wavelengths could only be computed after some detail in the spectrum had been identified, either from similarity with laboratory spectra or analogy with the other meteor spectra. Schwassmann's measures and identifications for Spectrum VIII and Blajko's measures for Spectrum II and Spectrum III were adopted. The remaining six spectra, as well as a few additional lines in Spectrum II, were measured by the writer. In the case of Spectrum III a remeasure of the chart plate showed that the spectrum had been originally placed on the dispersion scale too far to the red. A correction for this at once gave identification of all the lines with those found in other meteor spectra.

It was found that all the lines in meteor spectra could be identified with atomic lines of elements known to be present in meteorites. On the average, ionized calcium was the most prom-

inent feature of the spectra, the H and K lines appearing in six cases and in five of these being the strongest lines in the spectrum. Iron was identified in all the spectra. The difficulty encountered here was the small dispersion and low resolution that it was necessary to work with, the dispersions ranging from 150 to 450 angstrom units per mm. between H_γ and H_ζ. The iron lines are so numerous in the photographic region that no single line of iron could be identified with a single meteor line. The evidence of blended iron lines in all nine spectra, when they were considered together, was strong, however, and did not seem to leave much doubt that this element contributes a large fraction of the total photographic radiation of a meteor. Table II lists the elements identified in meteor spectra. The numerals indicate the number of meteoric lines identified with the element in question; *st*, that some of these lines were the strongest in the spectrum; *s*, strong but not the strongest; *m*, of medium strength; and *w*, weak.

TABLE II

Spectrum Atom	I	II	III	IV	V	VI	VII	VIII	IX
Fe	6 st	10 s	10 m	18 s	48 s	23 m	27 st	11 s	38 s
Ca		1 m		1 m		1 m			1 m
Ca+		2 st	2 s	2 st		2 st		2 st	2 st
Mg		1 s	1 st			2 m			
Mn		? m			1 s	1 m	1 m		1 w
Cr					4 st		? s		
Al		2 w				2 w			
Si					? w				? w

The multiplets of the above elements found in meteor spectra are all of low excitation, none having an upper level with an excitation greater than 6.0 volts above the lowest state of the atom. In a majority of cases they are the resonance lines. The elements in Table II agree fairly well with those found most commonly in meteorites. Elements common in meteorites which have not been identified in meteor spectra have no strong low excitation lines in the photographic region of the spectrum. Nickel might be considered a possible exception, but the only strong resonance lines of nickel in the range covered by the photographic data are at the

extreme violet end of this range where the definition is poor, and they are hopelessly masked by stronger iron lines. As for the visual region, observations made in the latter half of the 19th century (see references 1 to 16 at end), seem to give pretty strong evidence that the D lines of sodium are extremely common in meteor spectra and that the lines of magnesium at λ5170 also frequently appear. It is of interest to note that the meteor corresponding to Spectrum III was visually observed of a pure green colour and that the magnesium lines at λ3835 are by far the strongest in the photographic region of its spectrum. We may conclude then, that the elements identified in meteor spectra agree well with what we know of the average composition of meteorites.

It was noted that in all cases, except Spectra I and VIII where the resolution was very poor, the iron multiplets arising from the lowest level in the iron atom showed relative strengths two to six times stronger than in the iron arc as studied in the laboratory. This indicated a very low excitation of the iron vapour. By comparison of the observed multiplet intensities, as determined with the Moll microphotometer, with King's intensities in the iron spectrum at various furnace temperatures, it was possible to find a furnace temperature which corresponded to the state of excitation of the iron vapour surrounding the meteor. These effective temperatures, as they may be called, are given in Table III for the four spectra where microphotometer measures were possible. Owing to the absence of thermodynamical equilibrium in the meteor vapour it is incorrect to speak of true temperature in this connection.

TABLE III

Spectrum	IV	1680° A	±10°
"	IX Pos I	1790	10
"	IX " II	1770	25
"	V	1820	25
"	VII	2800	50

Pos I, Spectrum IX, corresponds to a faint part of the photographic trail; Pos II, to a sudden final bright burst where the meteor increased in photographic luminosity by a factor of 100. The probable errors were computed from the interagreement of various temperature estimates using different pairs of iron multiplets. The

actual probable errors are likely somewhat larger. A more detailed account of the above investigation is being published in the Harvard Annals.[22] Further work on meteor spectra is now being carried out at the Harvard Observatory under a fellowship from the Royal Society of Canada. This study will include an analysis of additional photographic material[23] secured in 1932.

BIBLIOGRAPHY

[1]A. S. Herschel, Intellectual Observer, *10*, 38, 1866.
[2]A. S. Herschel, Les Mondes, *7*, 139, 1865.
[3]A. S. Herschel, Intellectual Observer, *10*, 161, 1866; Report, Brit. Assoc., *36*, 142, 1866.
[4]A. S. Herschel, Intellectual Observer, *10*, 459, 1867; Report, Brit. Assoc., *37*, 399, 1867.
[5]J. Browning, Intellectual Observer, *10*, 465, 1867; M.N., *27*, 77, 1867; Phil. Mag., *33*, 234, 1867; Astr. Register, *5*, 7 and 27, 1867.
[6]J. Browning, M.N., *28*, 50, 1868.
[7]A. Secchi, Bollettino Meteorologica (Roma), *7*, 91, 1868.
[8]A. S. Herschel, Nature, *9*, 142, 1873.
[9]H. A. Newton, Am. Jour. Sci., *105*, 53, 1873.
[10]N. von Konkoly, Beob. O-Gyalla, *1*, 27, 1879; M.N., *33*, 575, 1873.
[11]N. von Konkoly, Beob. O-Gyalla, *1*, 27, 1879; M.N., *34*, 82, 1873; A.N., *82*, 289, 1873.
[12]N. von Konkoly, Beob. O-Gyalla, *1*, 27, 1879; A.N., *84*, 337, 1874.
[13]N. von Konkoly, Beob. O-Gyalla, *1*, 27, 1879.
[14]N. von Konkoly, Beob. O-Gyalla, *2*, 8, 1881; A.N., *95*, 283, 1879; Observatory, *3*, 157, 1879.
[15]N. von Konkoly, Beob. O-Gyalla, *3*, 7, 1881; Observatory, *3*, 577, 1880.
[16]N. von Konkoly, Beob. O-Gyalla, *5*, 19, 1883.
[17]E. C. Pickering, H.C., 20, 1897; Ap. J., *6*, 461, 1897; A.N., *145*, 77, 1897; M.N., *58*, 201, 1898; Nature, *57*, 101, 1897.
[18]S. Blajko, Ap. J., *26*, 341, 1907.
[19]W. P. Fleming, Pub. Am. Astr. Soc., *1*, 337, 1909; Science, *30*, 734, 1909.
[20]A. Schwassmann, Pub. Hamburg Obs., *6*, 106, 1928; A.N., *233*, 71, 1928.
[21]P. M. Millman, Pub. Am. Astr. Soc., *7*, 94, 1932.
[22]P. M. Millman, H.A., *82*, 113, 1932.
[23]P. M. Millman, H.B., 891, 1933

DESCRIPTION OF PLATE

A AND B—SPECTRUM V

Photographed May 18, 1909, with the 24-inch Bruce doublet at Arequipa, Peru. Two sections of the trail show difference in appearance owing to change in focus. A is from near the edge of the plate where the violet was in focus, B from near the centre of the plate where the focus was best in the blue and green. Spectrum shows 53 bright lines that have been identified with Fe, Cr and Mn. This was probably an iron meteor.

C—SPECTRUM IX

Photographed Dec. 15, 1931, at Blue Hill, Mass., with a 1.2-inch Voigtlander Skopar lens, aperture ratio F 4.5, and a 30 degree flint prism. Spectrum shows 42 bright lines and well illustrates what can be accomplished with small lenses of good quality. Lines have been identified with Ca+, Ca, Fe, and Mn. This was almost certainly a stone meteor. It was visually observed as of the brightness of Jupiter.

ARTIFICIAL TRANSMUTATION OF THE ELEMENTS*

By Lord Rutherford

Foreword

I GLADLY accede to the request of the Editor of *The McGill News* to give a brief statement of recent work in Cambridge on the transmutation of the elements for two reasons, one personal and the other historical. With regard to the first, I have always retained a lively interest in the progress of McGill University since my happy days there long ago, and this interest has been maintained by the migration of many research students from McGill to work with me in Manchester and in Cambridge. Now that nearly thirty years have passed since the first direct evidence was obtained of the transmutation of matter, I think we can view with some perspective the gradual development of our ideas on this subject. I would like to take this opportunity to emphasize that the credit of the first definite proof of atomic transformation belongs to McGill University. It was in the Macdonald Physics Building in the years 1902-1904 that Soddy and I accumulated the experimental evidence that the radioactive elements were undergoing spontaneous transformations. The disintegration theory, advanced in explanation of the observations, has stood the test of time and has formed the basis of all subsequent developments.

The next stage in advance was a proof that certain elements could be artificially transmuted by bombardment with the α-rays from radium, and it should be noted that it was in McGill, in 1903, that the true nature of this radiation, which played such a great part in the development of physics, was first disclosed. There is a saying that "it is the first step that counts", and it is clear that to McGill belongs whatever credit is due for the early ideas and experiments which opened up the way into the unknown that all subsequent investigators have followed.

In this article I have tried to give a brief and I hope understandable account of the gradual growth of our knowledge of the

*From *The McGill News*, September, 1932.

transmutation of matter—one of the most interesting and fundamental scientific problems in the world to-day.

History of Transmutation

The possibility of the transmutation of matter has always exerted a strong fascination on the scientific mind and much influenced the early stages of the development of science. We now know that the physical and chemical methods employed in the early attempts to produce transmutation were quite ineffective for such a purpose. A definite attack on this problem has had to await a clearer understanding of the structure of the atom and the development of methods for detecting individual atoms of matter in swift movement. The proof that the heavy radioactive elements were undergoing spontaneous transformations was a great step in advance and revived the dormant interest in the problem of transmutation. The study of these transformations gave us for the first time some idea of the powerful forces that must exist within the structure of atoms.

The atoms of the radioactive elements break up with explosive violence with the expulsion in most cases of a swift *a*-particle (helium nucleus), or in others with the ejection of a swift electron (*b*-particle). As the result of this explosion the resulting atom has entirely different physical and chemical properties. It may in turn break up and a whole series of successive transformations may occur. In this way more than thirty new transition elements of limited life have been brought to light. The processes occurring in the radioactive atoms appear quite uncontrollable by any physical or chemical agencies at our command. We can watch the explosions of these atoms, but are powerless to influence them.

The *a*-particles emitted from radioactive bodies are the most energetic projectiles known to science. They move so swiftly and have so much energy of motion that they can penetrate freely through the outer structure of the atoms, but suffer marked deflexion from their path if they approach closely to the minute charged nucleus which is a characteristic feature in the structure of all atoms. Indeed, it was from observations of the number and magnitude of these deflexions that the conception of the nuclear constitu-

tion of atoms first arose. These deflexions allow us to form some idea of the dimensions of the nucleus itself, at any rate in the case of the lighter atoms. It has been found that the radius of the nucleus, assumed spherical, must in general be very small, lying between 10^{-12} and 10^{-13} cm., so that the volume of the nucleus is minute compared with that of the atom itself as ordinarily understood.

It is important to emphasize a clear-cut distinction between the nucleus and the planetary electrons which surround it at a distance. By the action of light, X-rays, or by collisions with swift *a*- or *b*-particles, one or more of these outer electrons may be readily removed and indeed it is possible in some cases to strip the lighter atoms of all their outer electrons. By this loss of electrons, the ordinary physical and chemical properties of the atom are profoundly modified for the time, but yet at the earliest opportunity the nucleus captures new electrons from its surroundings and these take the place of the lost electrons. The atom thus regains its original state and no permanent change in the atom has been effected. If we wish to effect a veritable transmutation of the atom it is necessary to alter the charge on the nucleus or, what is equivalent, to remove one of the charged units which make up the structure of the nucleus itself.

It is believed that the two primary units comprising the nucleus are electrons and protons, but there is strong evidence that secondary more complex units may be formed by the combination of protons and electrons. The most important secondary unit is the *a*-particle, consisting of a combination of 4 protons and 2 electrons, and recently evidence of the existence of a neutron—a close combination of a proton with an electron—has been obtained. Both of these secondary units may form an essential part of the nuclear structure.

Artificial Transmutation

While the nucleus of an atom is a minute and strongly guarded structure, yet it seemed likely that a very swift proton or *a*-particle might be able to penetrate the nucleus of the lighter atoms and to alter its charge and mass. Following out these ideas Rutherford,

in 1919, bombarded nitrogen gas with swift α-particles from radioactive substances and found that high speed hydrogen nuclei, or free protons as we now term them, were liberated. For nearly 100,000 α-particles which pass through the gas on an average, only one swift proton was liberated. It was shown that these swift protons could only arise as a result of a close collision between the α-particle and the nitrogen nucleus. This was the first time that definite evidence had been obtained that an atom could be transmuted by artificial methods. In subsequent experiments by Dr. Chadwick and the writer, it was found that a number of the lighter atoms could be transmuted by α-particle bombardment. In all cases a proton was liberated with characteristic maximum speed and in the case of aluminium the energy of the ejected proton was greater than the energy of the bombarding α-particle. Certain light elements like carbon and oxygen appeared to be unaffected by α-particles.

The mechanism of this method of artificial transformation of atomic nuclei was brought out clearly by Blackett, who obtained direct evidence that in the case of nitrogen the colliding α-particle was captured by the nucleus, the disturbance resulting in the ejection of a proton. Since the α-particle has a mass 4 and charge 2, the nitrogen nucleus, of mass 14 and charge 7, is transformed by the capture of an α-particle and loss of a proton into a new element of mass 17 and charge 8, in other words into an isotope of oxygen. Subsequently a stable isotope of oxygen of mass 17 has been found to exist in ordinary oxygen. General evidence indicates that the transformation effected by α-particles in other light elements is similar in character. It is thus clear that the effect of α-particle bombardment leads to the building up of a heavier nucleus with an increase of 1 in the nuclear charge and an increase of 3 in the mass.

Neutrons

During the last few months the experiments of M. and Mme. Joliot and Dr. Chadwick have disclosed a new kind of transformation, brought about by the bombardment with α-particles, which occurs in the light elements beryllium and boron. It has been found that when beryllium is bombarded with swift α-particles no protons are emitted but instead a stream of swift uncharged particles of

mass about 1, "neutrons" as they have been termed. The neutron has very interesting properties,' for it passes freely through the atoms of matter in its path and only shows its presence when it collides directly with an atomic nucleus. In such a case the struck nucleus recoils and is detected by the dense ionization it produces in its path before being brought to rest. There is evidence that the neutron, unlike the *a*-particle, proton or electron, produces very little ionization in its passage through a gas, so that its presence can only be detected on the rare occasions when it strikes the nucleus of another atom. It is probable that the nucleus of beryllium of mass 9 and charge 4, captures the colliding *a*-particle and ejects a neutron with high speed. The atom of beryllium is thus transformed into an atom of carbon of mass 12 and charge 6. Feather has shown that the swift neutron also produces a novel type of transformation in nitrogen. In many cases an *a*-particle, instead of a proton, is ejected from the nitrogen nucleus. It will be of much interest to test whether the neutron is able to produce a transformation in other light elements besides nitrogen.

Recent Experiments

Since the nuclei of the atoms are very minute, it is only on rare occasions that the *a*-particle approaches closely enough to a nucleus to effect its transformation. For example, for every million *a*-particles fired into aluminium on an average, only one is effective in causing the ejection of a proton from the aluminium nucleus. Even with the strongest sources of *a*-particles available in the Laboratory, the effects observed are on a very small scale and detailed investigation has only been rendered possible by the development of powerful electric methods for registering the entrance of each individual proton into the detecting chamber. Progress in this problem would be much facilitated if far more powerful sources of swift bombarding particles of different kinds could be obtained by artificial methods. The importance of developing such new sources has been recognized for some time and many laboratories throughout the world have been trying out methods to achieve this purpose.

A suitable way for obtaining protons in great numbers is to pass an electric discharge through gas at a low pressure. For example,

the passage of a current of 1 milliampere through the tube corresponds to the bombardment of the cathode by about 6×10^{15} protons per second. To obtain an equal number of α-particles, we should require more than 100,000 grammes of radium. The speed of the protons generated in an ordinary discharge tube would, however, be much too slow to be effective for our purpose. In order to increase the speed, it is necessary to arrange that the protons should pass into a chamber, which is kept exhausted to a high vacuum by means of powerful pumps, and to apply a high potential to the ends of the chamber. The protons are thus accelerated in their passage through the intense electric field and for a potential difference of about 1 million volts acquire a speed comparable with that of the α-particles spontaneously emitted from radioactive substances.

During the past four years, Dr. J. D. Cockcroft and Dr. E. T. S. Walton have been preparing an installation in the Cavendish Laboratory to try out this method. Starting with a transformer which gives 200,000 volts, they have by special devices been able to obtain a steady D.C. potential of about 700,000 volts. This is applied to a large vacuum tube in which the protons are accelerated. Experiments were first made to determine the velocity and power of penetration of the swift protons produced in this way. It was found that, using 600,000 volts, the protons were stopped after their passage through about 1 cm. of air. Experiments were next made to test whether any swift particles were liberated from elements by this proton bombardment. The material to be bombarded in the form of a disc was placed at an angle of about 45° with the direction of the proton stream and the particles to be examined passed outside the tube through a small opening which was covered with a thickness of mica sufficient to stop any primary protons which fell upon it. For the detection of swift particles, the convenient and well-known scintillation method was first used, a zinc sulphide screen being placed close to the opening. The number of scintillations were counted with a microscope in a darkened enclosure.

Using a lithium target, a number of bright scintillations like those produced by α-particles were at once observed. The number was proportional to the proton current and increased rapidly as the accelerating voltage was raised. Using a proton current of about

a micro-ampere, a few particles were observed for as low a potential as 100,000 volts and a large number at 600,000 volts. In later experiments these particles have been examined by electrical methods as well as by the scintillation method, and there appears to be little doubt that they are α-particles which are liberated from the bombardment lithium. The particles have a definite range in air of about 8 centimetres and thus have greater swiftness than the α-particles spontaneously liberated from radium C, which have a range in air of 7 centimetres. It can be deduced that the energy of the α-particle from lithium is about 8,400,000 electron volts, while the energy of the bombarding particles may be as low as 100,000 electron volts, but it must be borne in mind that many millions of protons are required before one is effective in promoting the disintegration of the lithium atom.

From these observations, it seems likely that a proton is occasionally captured by the lithium nucleus of mass 7, and charge 3, giving rise to an unstable element of mass 8, and charge 4, which immediately breaks up into two helium nuclei, each of mass 4. If momentum is to be conserved, it is to be expected that the two helium nuclei should fly off in opposite directions. The correctness of this view admits of a simple experimental test which no doubt will be made in the near future. It is natural to suppose that the lithium nucleus of mass 7, normally consists of 1 helium nucleus, 3 protons and 2 electrons. The capture of the bombarding proton by the lithium nucleus in some way results in the combination of the 4 protons and 2 electrons to form a new helium nucleus or α-particle. It may be that the α-particles, which are believed to be the main constituents of the heavier nuclei, are always formed in situ within the nucleus itself. On the view outlined, the energy emitted during the transmutation of lithium is consistent with the conservation of energy as well as of momentum. The mass of the lithium nucleus, together with the mass of the swift proton, is greater than the masses of the two α-particles into which it breaks up. On the Einstein theory, a decrease of mass in a system involves a liberation of energy in some form. Calculation shows that the energy of motion of the two α-particles into which lithium disintegrates is in approximate accord with that calculated from the

change of mass involved. The whole process is thus consistent, as far as observation has gone, with the conservation of energy.

Preliminary observations have also been carried out on the effect of bombardment of other elements by protons. Boron, fluorine, aluminium, all give particles resembling α-particles, which have a definite characteristic range in air. Similarly, some particles are ejected from beryllium, carbon, nitrogen, calcium, potassium, iron, nickel, cobalt, copper, and silver, while the heavy elements, lead and uranium, show some effect. The number of particles liberated varies markedly from element to element. The results so far obtained are of a preliminary character and much detailed work with chemically pure elements will be required to determine the nature and energy of the ejected particles and of the residual nucleus. It may be that in some elements more than one type of transformation is possible and more than one type of particle is ejected.

Sufficient observations, however, have been made to indicate the importance and power of these new methods of investigating the transmutation of elements. It will be of great interest also to carry the experiments further and to examine the effects produced by swift bombarding particles of different masses, but obviously such experiments will involve much time and labour to carry out over a wide range of elements and over a wide range of voltage. It seems clear that this new method of attack, so successfully begun by Cockcroft and Walton, will, in the course of the next few years, give us much new information to help us in throwing light on the structure of nuclei and on the problem of the transmutation of the elements.

REVIEW OF PUBLICATIONS

The Expanding Universe by Sir Arthur Eddington. 128 pages, 4¾ x 7¼ in., with 2 pl. Cambridge University Press: Macmillan Co. of Canada. Price, $1.00. 1933.

During the meeting of the International Astronomical Union at Cambridge, Mass., last September, Sir Arthur Eddington gave a lecture on The Expanding Universe. It was delivered in the Walker auditorium of the Massachusetts Institute of Technology to an overflowing audience. A little later Sir Arthur gave three talks over an American radio chain on the same subject. This book contains the substance of these addresses in an extended form.

The preface states the author's object in a clear and interesting way, as is illustrated by the following two paragraphs from it.

I deal with the view now tentatively held that the whole material universe of stars and galaxies of stars is dispersing, the galaxies scattering apart so as to occupy an ever-increasing volume. But I deal with it not as an end in itself. To take an analogy from detective fiction, it is the clue not the criminal. The "hidden hand" in my story is the *cosmical constant*. In Chapter IV we see that the investigation of the expanding universe falls into line with other methods of inquiry, so that we appear to be closing down on the capture of this most elusive constant of nature.

The book will be found of uneven difficulty; and the reader who finds himself out of his depth in Chapter II may discover that the going becomes easier further on. I have endeavoured to make the explanation as simple as possible; but the book is not intended solely as a semi-popular exposition, and I have not hesitated to plunge into matters of extreme difficulty when it seemed necessary for an adequate discussion of the problem.

As many thousands know, Sir Arthur Eddington has a style all his own. He has a deftness in putting together the most appropriate words and a whimsical humorous sense which is very attractive. Even when grappling with something which is glimpsed very imperfectly or is just beyond his mental ken, but which mathematical

analysis assisted by a sort of mystical intuition makes him feel certain of its existence, he is always interesting and inspiring. The book is small in size but it should be read more than once as it gives a suggestive peep into the deepest mysteries of the physical universe.

C.A.C.

Amateur Telescope Making, edited by Albert G. Ingalls. Third Edition, 500 pages, 5½ x 7½ in. N.Y. Scientific American Publishing Co., 1933. Price, $3.00.

The second edition of this book was reviewed in the December 1928 issue of this JOURNAL and four years later many thousands were waiting eagerly for this third edition which is almost 60 per cent. larger. The able and lively editor of the book must feel satisfaction in the success of his efforts, since the wonderful movement for the manufacture of telescopes has spread all over the continent and far beyond it. He and the *Scientific American,* of which he is an associate editor, deserve the highest commendation.

The new edition includes what was in the old with revisions, and also a multitude of new features—flat making, solar spectroscope making, celestial photography, accuracy in parabolizing, simple clock drive, new instructions in silvering (anticipating all the pitfalls), polarization test for strain, binocular telescopes, eyepieces, and many others. There are also new lists of books, materials and societies. Indeed the book is encyclopedic in scope, and its information is up to the minute. It is illustrated with a profusion of photographs and drawings, and to anyone who proposes to make a telescope the book is simply indispensable.

C.A.C.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

A Bright Meteor seen in Daylight—By H. W. Barker.

On Wednesday evening, February 22, about 6.15 o'clock, I was walking along Fallingbrook Road, Toronto, near my home when I was attracted by a meteor in the eastern sky about half way between the horizon and the zenith. It seemed to drop almost straight down like a sky-rocket. The sun was just about setting and the sky was overhung slightly with clouds, but it was almost broad daylight. The meteor appeared suddenly and shone with a brilliant incandescent light for perhaps five seconds, emitting sparks as it fell. Having dissipated itself it died out just above the tree-tops in the woods on the east side of the street. It appeared to be very close, and yet there was no sound. Had it appeared in the night, I am sure it would have illuminated the whole landscape. On entering the house I referred to the "Observer's Handbook" and noticed that this was the period for the Aurigids, and the meteor which I have tried to describe had come from the direction in the sky where the constellation Auriga was at that hour. This was the first meteor I had ever seen in daylight, and I have been wondering if it was observed by many others.

This fireball was seen by Miss L. Pallett, a University of Toronto student, from a point west of Islington, and about fifteen miles west of Mr. Barker's home. Her description agrees closely with that given above. One would expect this object to have been seen at points forty or fifty miles farther east, but no reports have been received.

The Pleiades Riding over a Hill—By Oscar E. Monnig, Ft. Worth, Texas.

The following quotation is from "Mexico" by Stuart Chase (Macmillan, 1931), pp. 46-7.

The Aztecs borrowed the Maya principles but never achieved such mathematical elegance. . . . . They worked from a fifty-two-year

cycle, initiated with great ceremony when the Pleiades came riding over a certain hill near Popocatepetl. To paraphrase Prescott:

> ". . . . .On the evening of the last day a procession of priests . . . . . moved from the capital towards the mountain. On reaching its summit, the procession paused—till midnight; when, as the constellation of the Pleiades approached the zenith, the new fire was kindled. . . . .a new cycle had commenced. . . ."

The last celebration before the conquest was early in Montezuma's reign, in 1507. In the present year (1931), the Pleiades climb that hill again, and though no such marvellous and dramatic pageant will greet their eyes, I should not be surprised if in one or two remote outposts the drums would sound. . . . . (pp. 46-7)

Possibly the writer did not intend to convey the impression that the Pleiades rise and reach the meridian only once every 52 years, but I know those unused to astronomical contemplation get that impression—as one reader did, who called the above to my attention! Only one revolution of the skies in 52 years!

A Thirty-inch Steel Reflector

It is interesting to see the widespread activity of amateurs in the construction of telescopes. This is shown by notes in various publications, especially in the *Scientific American* which has a budget of news with numerous illustrations every month. Indeed that magazine, never more vigorous during its long life of eighty-eight years, is doing an inspiring work in these days of financial depression. Few of these instruments are in the same class as that undertaken by Mr. William Gore, a consulting engineer of Toronto, who gives the following account of his project.

I have commenced the construction of a 30-inch reflecting telescope using heavily ribbed castings of stainless steel for the reflectors. The form of the telescope will be approximately that of the Cassegrain but it is proposed to secure a combination whereby all light rays from a distant source parallel with the line of collimation entering the telescope will be of the same length to a fraction of a wave-length of blue light. By a somewhat laborious process of trial and error I find that this will be secured if the 30-inch reflector is figured from the sphere to a little more than twice as much as for a paraboloid. The equation to a diametrical cross section of the 30-inch reflector expressed in inches works out as

$$Y^2 = 480X + 1.02879X^2.$$

Similarly for the small reflector 7 1-2 inches in diameter placed 95 inches in front of the large one and reflecting to a focus at 100 inches distant, or 5 inches behind the face of the large reflector, which is perforated, works out at

$$1.5y^2 - 0.00105175y^4 = 200x + x^2.$$

These equations have been worked out so that the X and x will be accurate to one one-hundred thousandth of an inch but it seems probable that another decimal point will be necessary.

Assuming that the practical difficulties of figuring the reflectors and of securing the proper mounting can be overcome, it is anticipated that the diffraction rings with this combination will be a minimum.

The equivalent focal length of the combination is 40 feet but the telescope will swing in a circle of diameter 12 feet, and it is hoped that when mounted equatorially at my residence at Long Branch it will be of some use for photographic work when applied to points high in the heavens.

The reflectors, machined to the approximate spherical surfaces, have been prepared by Thomas Firth and John Brown Limited and are of a material described by the manufacturers as "Firths Staybrite" which I have been given to understand is a chrome-nickel-iron with austensitic characteristics, tough and close in texture with very high surface stability, and while harder than glass to grind and polish should be quite suitable for amateur work, avoiding the necessity of silvering and of frequent resilvering. It is hoped that the open ribs will allow the inevitable temperature changes to take place freely without distortion of the surfaces of the reflectors.

Behaviour of Bees at the Eclipse of the Sun

A friend who lives about one hundred miles north of Toronto has some sixty hives of bees and reports that they behaved in a curious way during the eclipse of the sun on August 31, 1933. The eclipse was partial, having a magnitude of about 92 per cent. The day was fine and the bees were busy, but as the eclipse progressed they apparently felt the diminution in the light and became nervous. Usually as night comes on they return leisurely, but as maximum eclipse approached and darkness came rapidly they got in a panic and flew home in myriads, piling themselves up on the lighting- boards to the depth of two or three inches.

C.A.C.

MEETINGS OF THE SOCIETY

At Vancouver

January 10, 1933.—The thirteenth regular meeting of the Vancouver Centre was held at the University of British Columbia. The President, Mr. Teasdale, was in the chair.

Mr. Paul Sykes gave the talk on the stars for the month.

Mr. H. C. B. Forsythe then introduced the speaker of the evening, Mr. Teasdale, whose subject was "Telescopes for Amateurs".

The speaker dealt briefly with the development of telescopes from the simple forms of Galileo and Kepler to modern refractors and reflectors. Properties of convex and concave lenses were explained, the causes and effects of spherical and chromatic aberration were outlined, and the means devised from time to time for their correction and compensation described. Crown and flint glass, and the advances made in their quality, as bearing on the telescope were touched upon and their combination in the achromatic telescope explained.

With reflectors, it was shown that progress was delayed by the difficulty in working non-spherical curves; that, when parabolic surfaces were eventually produced, the reflector for a time quite eclipsed the refractor. Modern forms of both were then described, and compared, both generally and from the point of view of the amateur.

Several types of eyepieces were described and their application to various classes of work discussed. Altazimuth and equatorial mountings were touched on and compared.

Simple methods of testing quality of performance of telescopes by means of star images were outlined. Seeing conditions and the effects of atmospheric refraction were discussed and reference made to local conditions.

The various classes of observation available to the amateur were enumerated, viz.: lunar surface, planetary detail, variable and double star work, and suitable magnifying powers for these classes were suggested.

It was mentioned that there were still possibilities for the amateur of useful work and even original discovery, although the field is well covered professionally; but it was pointed out that such a programme was not necessary, that a great deal of intellectual exercise and recreation was to be obtained from repeating and checking observations already well known and in thus personally building up a fund of astronomical knowledge. Such a line of study it was claimed might be quite as profitable as the former one in enriching both mentally and spiritually the inner life of the amateur astronomer.

William Ure, *Recorder.*

AT MONTREAL

March 3, 1932.—The third meeting for the session 1932 was held at 8.30 p.m. Dr. L. V. King in the chair.

New members duly were elected:

Miss K. M. Lighthall	Dr. Neil Feeney
Mr. G. R. Lighthall	Dr. C. R. Bourne
Mr. W. F. Carsley	Dr. H. Segall
Miss H. M. Graham	Dr. W. W. Francis

Mr. E. C. T. Chapman (transferred from Victoria Centre)

The Treasurer announced a gift of $25.00 for the fifth consecutive year from a member of the Society.

Dr. W. W. Francis exhibited three books from the Osler Library:

1st Edition 1543 Nuremberg of Copernicus' "De Motu . . ."
1st Edition 1632 Galileo's Dialogue.
1st Edition 1687 Newton's Principia.

The lecturer, Professor A. H. S. Gillson, was then called upon to address the society on "The Mechanics of the Universe". A summary by Mr. K. Dunn is appended in the minute book but is not here reproduced.

Announcement was made of the coming visit of Prof. E. W. Brown of Yale, on March 31, and also of a lecture on the 1932 August 31 total solar eclipse, if the society expressed a desire to have this, by the secretary. After a vote of thanks to the speaker, Prof. Gillson, and to Dr. Francis for bringing the exhibit of books, the meeting adjourned.

March 31, 1932.—This was the fourth meeting. The President, Dr. L. V. King, in the chair.

New members elected:

Rev. J. H. Thomas	Mr. G. Signori
Rev. C. H. Dickinson	Mr. R. S. Logan

The lecturer was Prof. E. W. Brown, F.R.S., Yale University, and his subject, "Time—Its Measurement and Determination".

All time is "man-made". A clock is anything measuring the passage of time. An old philosophy defines time as a succession of ideas.

A clock consists essentially of something fixed and something moving, a dial and a pointer. Let the pointer be a transit circle, and the interval from a star to the same star is one sidereal day. Consider as clocks, earth, moon, sun, planets and think of the inevitable errors of observation. The jagged edge of the moon introduces errors in observations of eclipses and occultations. The sun's limb is "boiling"; planets and satellites have no clear edge.

Axial rotation of earth varies in two ways—(1) tidal friction produces lengthening of day; (2) oscillating effects only recently discovered—

1660-1790 earth went fast by 30″ approx.
1790-1895 earth went slow by 30″ approx.
It is now running fast since 1918.

These abrupt changes must be due to internal causes; constant angular momentum demands change in period of rotation if readjustments of the distribution of matter take place deep within earth.

Pendulum clocks, and especially the Shortt clocks, give subdivisions of the day. Unlike the proverbial Irish pig, the Shortt slave clock tries to run ahead and give impulse to the main pendulum. The Greenwich Shortt clock since 1926 has been losing time, 4 sec. in two years. Twelve such clocks would give a good check on the rate of the earth's rotation.

The crystal oscillator keeps time with extreme exactitude, oscillating 100,000 times per sec. Loomis' chronograph comparing crystal oscillator and Shortt clocks records differences to 1/1000 sec. The analyses of such records indicate diurnal and lunar periodicities and pillar vibrations as small as a wave length of light.

Professor A. H. S. Gillson proposed a vote of thanks, saying that there were great moments in life not measurable with clocks, and the privilege of listening to great men like E. W. Brown, a worthy successor to Newton in the line of celestial mechanics, was an experience of such an immeasurable character.

After comments by Dr. A. S. Eve, Prof. W. L. G. Williams and Dr. W. D. Lighthall, the meeting adjourned.

April 21, 1932.—The fifth meeting took place in the Mechanics Institute, when a public lecture in the Mechanics' Institute series was given by Dr. A. Vibert Douglas on "The 1932 Total Eclipse of the Sun." The chair was taken by Dr. L. V. King.

No summary of this lecture is thought necessary.

May 25, 1932.—The sixth meeting was held in the MacDonald Physics Laboratory jointly with the McGill Physical Society and the Society of Sigma Xi.

The lecturer was Professor A. N. Whitehead, F.R.S., D.Sc., from Harvard University (late of London and Cambridge).

The following notes will indicate the trend of his remarks:

Physicists are thinking more of philosophy—an effort to find thoughts by which men guide their lives and their imaginative construction of the world. Two classes or casts of mind exist—those who believe philosophy has no bearing on science, and those who think it has the very deepest bearing.

Certain things are known about the world certainly and distinctly, the background forever unknown. Epicurus thought philosophy had nothing to do with science—physical world simply bits of matter. That is one attitude.

But after 2500 to 3500 years the problem is less simple. Consider the imaginary images produced in the brain by drink and cocaine. Consider the molecular motion picture, molecules, atoms, sensations—this obvious world vanishes—is it all an illusion? This is a "silly point to have reached." "*No* external world, is an idea too silly for words, but it is a tremendous puzzle." Sense perceptions are not adequate to give us that we believe. All science is built up on categories of thought that sense perception cannot give. Any object you see is just itself at this moment—no past, no future, no message.

Santayama said: "Sense perception alone is not sufficient—memory has an essential part."

Hume's explanation is not satisfactory—anticipation of the future comes from experience of the past.

The human body and mind form an essential unity, and realization of this is an essential character of mind. This sense of unity is not a sense perception, it is a "massive feeling". We derive our emotional state from the body as it was at least 1/1000 sec. ago. The mind has an irresistible persuasion that it is deriving from the body in the past. Anger, for example, is derived from the past. Our experiences have elements of clarity by superficial, pragmatic importance, but metaphysically unimportant. How do you arrange your state of mind? How determine the kind of being you are? (*a*) by sense, (*b*) by a massive feeling, indistinct, but unescapable?

After observation of sense data, interpretation is dependent on categories derived from the past, from the other side of the mind—intuition. The "positivists" take a short cut and "deny the facts", *i.e.* all science is doing is to describe what has happened in respect to the flux of sense data.

(1) But is is very odd that their description is not in terms of sense data, *i.e.*, see Maxwell's equations and the fairy tale of protons, electrons and photons.

(2) If they are giving merely a description, then let them describe; but science is full of words ending in "ible" and "able". Sense perception does not know such words as those, nor "may, might, should". Further, they should not talk about the future (he holds up piece of paper and then drops it). No one foretold the falling of this paper by *looking* at the paper.

Thus we do not believe science is merely the routine of describing the fact observed. Science's importance depends on some element of experience not provided by sense data.

Hume says belief arises from custom. "I can call spirits from the vasty deep" (Hotspur). "But will they come when you do call?"

We have direct knowledge of the derivation of the present from the past, but not from our senses. It is the task of philosophy to get straight in some way the notions concerning this mysterious bond of past and present,—the past issuing into the present, the present into the future; notions of what are the actualities of the world and their conditioning.

Philosophy is guided largely by science, since science is evidence of experience. Science weaves partial theories. There can be no complete separation of the various topics of experience, *e.g.*, science and theology always at odds for each is limited in ways it cannot define and a coalescence of the experience of each is necessary.

Philosophy has the task of getting notions never yet wholly entertained in human experience and of gathering the flashes of genius (as in Plato) to form an imaginative capital from which each science can draw as its epoch closes. If no philosophy, then eventual stagnation. Philosophy is that spark of madness

which makes the joy of life—the glory of morals and religion—and an engine for progress.

In reply to questions, Dr. Whitehead added, this "touch of madness" is a normal impulse in man, it is the primordial drive in the universe known as the impulse towards ideals now impossible and never realized. This drive is the reason for the tendency towards order in the universe—not a static order—types of order are evolved.

After some discussion and a very hearty vote of thanks, the meeting adjourned.

October 27, 1932.—The first meeting of the new session was held in the Macdonald Physics Laboratory. In the absence of the President, the Vice-President, Dr. Julian C. Smith, took the chair.

The reports of the Secretary and Treasurer for the past year were read and adopted.

The Secretary moved a vote of thanks to Mr. A. O. Ferrier (certified public accountant) for his generosity in auditing the society's accounts.

Judge E. E. Howard moved a vote of thanks to Dr. A. S. Eve for his kindness in again giving the use of the physics lecture theatre for the meetings of the society.

Dr. Eve moved a vote of thanks to the Secretary.

The slate of officers as drawn up by the Council was voted in unanimously and the new President, Mr. Geo. Harper Hall, took the chair.

The topic of discussion was "The 1932 Total Solar Eclipse."

Dr. Eve reported on the radio results.

The President reported on the observations made by himself and his party, showing slides of the corona made from his own photographs. As his report has been published in this JOURNAL, no details are here given, but different observers have described the colour of the corona in such diverse ways that his list of replies from members of his party is here reproduced:

Silver white (3), white, silver grey, diamond, cream white, silver, dark silver, pure white, yellow red, "not yellow nor red nor blue nor green nor purple."

Mr. Muncaster showed slides of the equipment and of the astronomers and physicists at Magog. Mr. Wynn described the behaviour of night moths, ants and crows. Dr. Eve reported on the radiation work of Dr. Shaw and Mr. Katzman. Dr. W. D. Lighthall, Mr. George Lighthall, and Judge E. E. Howard described various features observed by them.

After general discussion the meeting adjourned.

December 8, 1932.—The second meeting was held in the usual place. Mr. G. Harper Hall in the chair.

New members were elected as follows:

W. H. Rawlings E. S. Booth

The Secretary referred to the death of Mr. J. Luttrell, at one time a member of the Council. The Secretary also reported the purchase of a seven-foot focal length Aitchison telescope from Mr. H. E. S. Asbury. This was on view in the hall.

The lecturer, Dr. A. Norman Shaw, F.R.S.C., then gave a most interesting and informative lecture on "Some Fundamental Experiments in Thermal Radiation."

These beautiful experiments illustrated conduction convection and, in particular, the properties of radiation and its detection by thermopiles, Kata thermometers, etc. The audience thoroughly appreciated this demonstration and explanation and several questions were asked and answered, after which Mr. Geo. Lighthall moved a vote of thanks.

February 2, 1933.—The third meeting was held in the auditorium of the Montreal High School, kindly put at the disposal of the McGill Physical Society and R.A.S.C. for their joint meeting.

Dr. D. A. Keys, F.R.S.C., President of McGill Physical Society, took the chair at 5 p.m. and introduced the speaker, the Abbé Georges Lemaître of Louvain.

Abbé Lemaître delivered a lecture on the "Expanding Universe" to an audience of a thousand or more people. He discussed the age of the earth and radioactivity, the evidence of cosmic radiation and the hypothesis which he has formed of successively higher atomic weight atoms in past ages, all originating "in the beginning" from one primeval atom. He then outlined the basic ideas associated with a model or map of the universe, finite but unbounded and of expanding radius, referring to the evidence of the nebulae.

The density of a nebula is estimated to be 10^{-31} gm/cc. and the density of radiation in space is 10^{-34} gm/cc. This cosmic radiation, as also cosmic electrons, cosmic alpha particles and possibly cosmic iron, and other most abundant atoms which may be detected, would offer evidence in favour of the hypothesis of the primeval atom and super-radioactivity of the now non-extant atoms of an early stage of evolution of the universe.

A vote of thanks was proposed by Dean A. S. Eve, F.R.S.

The thanks of the society are due to the principals of the Montreal High School for boys and for girls for their generous offer of the school auditorium. No McGill university hall would have accommodated the great audience that assembled to hear this lecture.

A. V. Douglas, *Secretary*.

At Winnipeg

December 14, 1933.—The regular monthly meeting was held in the University Science Building at 8.15 p.m. The president, Dr. Neil John MacLean, was in the chair.

The speaker of the evening, Dr. L. A. H. Warren, referred to the unusually great activity at the present time in the making of telescopes. "Never in the history of astronomy," said Dr. Warren, "has there been such a rush in regard to the making of new telescopes." He gave as instances: the 80-inch reflecting telescope of the University of Texas soon to be begun; the new 74-inch reflecting telescope of the David Dunlap observatory in connection with the University of Toronto; the new observatory about to

be built on Mt. St. Katherine, a desolate peak in the Siana desert, 8,500 feet above sea level; the recently completed observatory at Delaware, Ohio; the observatory about to be built in South Africa, and the 200-inch telescope for the California Intstitute of Technology. Men of wealth were making generous contributions towards the construction and erection of large modern telescopes.

Speaking of Sir William Herschel, the first president of the Royal Astronomical Society, Dr. Warren told of his boyhood interest in astronomy, how in an effort not only to know but to discover, he had the use of a small telescope in May 1773, through which he caught a preliminary glimpse of the rich and varied fields to the study of which for many years, he was to devote his life. What he saw through this small telescope made him wish to have one for himself, but as the price was prohibitive, he determined to make one. Herschel made his first recorded observation on March 4th, 1774, using the telescope which he, himself, had made. The construction of this instrument in his 36th year, may be regarded as the beginning of his astronomical career. He was not satisfied with his first telescope, he made for his own use another, and two after that, four in all, each instrument being larger and more powerful than the preceding one. With these he reviewed the whole heavens. If he saw anything in any way remarkable, he made a record of it and a more careful study when necessary. In 1781 Herschel discovered the planet Uranus. Since then only two major planets have been discovered—Neptune in 1841 and Pluto in 1930. The lecture was fully illustrated.

S. C. Norris, *Sec.*

At London

At London.—Dr. H. R. Kingston, of the University of Western Ontario, was the speaker at the February meeting taking for his subject the planet Mars. He said the interest in this planet was more wide-spread than that in most other celestial bodies. With the ordinary person the interest lay in the question as to whether or not the planet was inhabited, but to the astronomer it was a question of conditions there that might support life.

The characteristics of the planet were frequently compared with those of the earth. The length of day is about the same as ours; the seasons, though about twice as long, vary as ours do. There is a depth of atmosphere of about 120 miles surrounding the planet but much rarer than that of the earth. The Martian day and night must show a greater variety of temperature. This might range from 70 degrees in the day time to 120 degrees at night.

A picture of the movement of Mars and the earth around the sun was shown to illustrate why, at about the time of opposition Mars seems to us to change from a direct to a retrograde movement among the stars. Another picture showed the orbit of Mars more eccentric than that of the earth. It was pointed out why the opposition that occurred in August, 1924, gave so much better observation of Mars than any other in the 15 year period.

The two moons of Mars were discovered in 1877 by Asaph Hall of the Naval Observatory at Washington. The inner moon makes a revolution around the planet in about one-third of the time Mars takes to rotate. Hence to a Martian this moon would rise in the west and set in the east, and all the phases might be seen in one night.

Interesting photographs of the planet taken in different wave-lengths were shown, the ultra-violet light showing only the atmosphere surrounding the planet while the infra-red penetrated to the solid body beneath.

An amusing illustration of the visit of a party of Martians to our earth brought this very interesting lecture to a close.

N. MORRIS, *Secretary-Treasurer.*

AT TORONTO

February 14, 1933.—A regular meeting was held at 8 p.m. Mr. R. A. Gray in the chair.

There were ten elections to membership:—

John A. Anderson, 64 Park St., Brockville, Ont.
H. S. McClung, 813 McCallum Bldg., Regina, Sask.
D. B. Keffer, 1437 King St., Regina.
W. Frank Marshall, 2068 McIntyre St., Regina.
W. A. Warren, 107 34th Avenue, Lachine, Que.
Rev. Fr. Leo Morin, Au College, Ville St. Laurent, Que.
Gene W. Rossman, 295 Culpepper Terrace, Portland, Ore.
Walter Hopkins, 18 Gulich Avenue, Clearfield, Pa.
Alfred Boyles, 2710 Avenue I, Ensley, Alabama.
Dr. A. Elgin Towle, 229½ Jones Avenue, Torono.

A description of "Taurus" and neighbouring groups of stars, illustrated by slides, was given by Mr. A. R. Hassard.

The lecture of the evening was by Prof. D. S. Ainslie, Ph.D., on "Electrical Instruments for Astrophysical Measurements." The speaker confined the address to the discussion of the construction and use of vacuum thermocouples, photoelectric cells, and accessory equipment employed in recent years for the measurement of stellar radiation. He described the construction of sensitive vacuum thermocouples, by which accurate measurements are secured by the radiation from stars of magnitude 6 to 7. The thermocouples are constructed of wires about one ten-thousandth of an inch in diameter, mounted in an evacuated cell, and connected with a sensitive galvanometer, so that they were capable of giving a measurable galvanometer deflection for a temperature rise of one three-thousandth of a centigrade degree. An estimate of the character of the radiation was obtained by noting the change in the deflection produced by inserting a water cell in the path of the light. The water cell exercised a selective absorption effect, cutting out a large part of the red and infra-red portions of the radiation.

More recently A. E. Whitford has been able to amplify stellar radiation two million times and measure accurately the radiation from stars of a magnitude of 9.

Dr. Ainslie gave many interesting demonstrations to illustrate the various types of electrical equipment described in the lecture.

February 28, 1933.—A regular meeting was held at 8 p.m. Mr. R. A. Gray in the chair.

There was one nomination for Life Membership:—

Mr. Ernest L. Neill, 507 So. Robinson St., Cleburne, Texas. Mr. David W. Roseburgh, Poughkeepsie, N.Y., was made a Life Member by paying the fee of $25.00.

The predictions for the succeeding two weeks were given by Mr. F. L. Troyer. Mr. H. F. Balmer, M.A., then addressed the meeting on the subject "Man's Place in the Universe." The speaker outlined man's own changing ideas of his physical position in the universe from early ages to the present era. The early people believed that they were the chief concern of all creation, living on a fixed, flat earth, with a floating inverted sky. Ptolemy, in the 2nd century A.D., finding that this theory could not account for the observed motions in the sky, postulated a geometric system, the planets revolving about the earth in circles. Since the Creator was perfect, and the circle a perfect figure, therefore the orbits of the planets had to be circles. Copernicus changed the geocentric system to a heliocentric universe, but he did not doubt the circularity of the orbits. Later Kepler changed the orbits to ellipses. Up to this time the proof of a statement was to be found in books, not by experiment. In 1609 Galileo through his telescope observed startling things supporting the Copernican theory, but the church taught that the earth was the centre of the universe, and so Galileo had to deny what he saw.

But the truth could not be suppressed, and in time the heliocentric idea became generally accepted. Through the work of Bradley, Herschel and Shapley we now believe the universe to be disc shaped, about 250,000 light years in diameter, with man unthinkably small, and about 55,000 light years from its centre.

Finally Mr. Balmer discussed some other relations of man in the universe. His possessions are unmeasurably small, and perhaps his very life is due to an accident among the stars. We know little of our true significance, we see as through a glass darkly, and in generations will see a little more.

Mr. Gray then gave the constellation study for the evening on "Scorpio" illustrated with slides.

G. Hepburn, *Recorder.*

The Royal Astronomical Society of Canada

OFFICERS FOR 1933

Honorary President—Mgr. C. P. Choquette, M.A., Lic.Scs., Montreal.
President—R. K. Young, Ph.D., Toronto.
First Vice-President—Lachlan Gilchrist, M.A., Ph.D., Toronto.
Second Vice-President—R. E. DeLury, M.A., Ph.D., Ottawa.
General Secretary—R. A. Gray, B.A., 198 College St., Toronto.
General Treasurer—J. H. Horning, M.A., 198 College St., Toronto.
Recorder—E. J. A. Kennedy, Toronto.
Librarian—R. A. Gray, B.A., Toronto.
Curator—R. S. Duncan, Toronto.
Council—D. S. Ainslie, M.A., Ph.D., Toronto; F. Napier Denison, Victoria; Miss A. Vibert Douglas, Ph.D., Montreal; Wm. Findlay, Ph.D., Hamilton; E. A. Hodgson, Ph.D., Ottawa; A. R. Hassard, K.C., Toronto; J. A. Pearce, Ph.D., Victoria, B.C.; J. Patterson, M.A., Toronto; John Satterly, M.A., D.Sc., Toronto; L. A. H. Warren, Ph.D., Winnipeg; and Past Presidents—Sir Frederic Stupart; C. A. Chant, M.A., Ph.D.; A. T. DeLury, M.A.; L. B. Stewart, D.T.S.; J. S. Plaskett, D.Sc., F.R.S.; A. F. Miller; J. R. Collins; W. E. W. Jackson, M.A.; R. M. Stewart, M.A.; A. F. Hunter, M.A.; W. E. Harper, M.A.; H. R. Kingston, M.A., Ph.D.; and the Presiding Officer of each Centre as follows—R. Glenn Madill, B.A., Ottawa; G. Harper Hall, Montreal; A. W. Megget, Winnipeg; Philip H. Hughes, Mus. Bac., Victoria, B.C.; George Gunn, London; W. S. Mallory, M.A., Hamilton; J. Teasdale, Vancouver; Prof. E. S. Keeping Edmonton.

TORONTO CENTRE

Honorary President—Sir Frederic Stupart
Vice-Chairman—A. R. Hassard, K.C.
Treasurer—J. E. Maybee
Curator—R. S. Duncan
Observation Committee—Dr. C. A. Chant, J. R. Collins, A. R. Hassard, A. F. Hunter, Dr. D. B. Marsh.
Chairman—R. A. Gray, B.A.
Secretary—E. J. A. Kennedy
Recorder—S. C. Brown
Asst.-Curator—F. L. Troyer

OTTAWA CENTRE

Honorary President—J. S. Lane, B.A.
President—R. Glenn Madill, B.A.
Vice-President—A. H. Miller, M.A.
Secretary—Miriam S. Burland, B.A., Dominion Observatory, Ottawa
Treasurer—A. W. Grant, B.A.
Council—N. A. Irwin, B.A.; J. P. Henderson, M.A.; J. McLeish, B.A.; and Past Presidents—R. M. Stewart, M.A.; R. E. DeLury, Ph.D.; K. J. McDiarmid, Ph.D.; C. R. Coutlee, C.E.; C. C. Smith, B.A.

MONTREAL CENTRE

Honorary President—Mgr. C. P. Choquette
President—Geo. Harper Hall
First Vice-President—Dr. D. A. Murray
Second Vice-President—Dr. Julian C. Smith
Secretary-Treasurer—Dr. A. Vibert Douglas, Physics Building, McGill Uniersity
Council—Dr. A. S. Eve; Justice E. E. Howard; Lt.-Col. W. E. Lyman; H. E. S. Asbury; Dr. A. H. MacCordick; Dr. L. V. King; Prof. N. B. McLean; Dr. W. D. Lighthall; A. D. Ferrier.

LONDON CENTRE

Honorary President—H. R. Kingston, M.A., Ph.D.
President—George Gunn
Vice-President—Major E. H. Anundson
Secretary-Treasurer—Miss N. Morris, 103 Elmwood Avenue
Council—Miss A. Callard, Mrs. W. P. Burns; S. J. Versteeg; D. M. Hennigar; and Dr. H. S. Wismer.

WINNIPEG CENTRE

Honorary President—J. S. Plaskett, D.Sc.
President—A. W. Megget
Vice-President—D. R. P. Coats
2nd Vice-President—Prof. V. W. Jackson
Treasurer—J. H. Kolb
Secretary—Mrs. J. Norris, 509 Sherburn St.
Assistant-Secretary—Mrs. J. C. Howey
Council—Dr. N. J. McLean; C. E. Bastin; L. T. S. Norris-Elye; A. V. Pigott; F. Pugh; Mrs. H. M. Sweet; Mrs. E. L. Taylor; Dr. L. A. H. Warren.

VICTORIA CENTRE

Honorary President—James Duff, M.A.
President—Philip H. Hughes, Mus. Bac.
1st Vice-President—N. C. Stewart, C.E., B.C.L.S.
2nd Vice-President—Charles Hartley, M.A.
Secretary-Treasurer—H. Boyd-Brydon, 2390 Oak Bay Ave.
Council—G. Browne-Cave; W. Burton; T. J. Greenway; F. S. Hogg, Ph.D.; W. F. Holdridge; H. E. Moore, M.A.

HAMILTON CENTRE

Honorary President—Rev. Dr. D. B. Marsh
President—W. S. Mallory, M.A.
Vice-Presidents—W. T. Goddard, B.Sc.; T. H. Wingham, B.A.Sc.; Prof. Wm. Findlay
Secretary—J. A. Little, B.A., 9 South Oval
Treasurer—G. E. Campbell
Curator—W. T. Wingham; *Council*—Dr. G. M. Jackson; W. G. Milne, E.E.; S. C. Scammell; Mrs. S. C. Scammell; Prof. A. E. Johns; J. A. Marsh; Rev. John Samuel; I. H. Waring.

VANCOUVER CENTRE

Honorary President—Dean D. Buchanan
President—J. Teasdale
1st Vice-President—H. C. B. Forsyth
2nd Vice-President—F. R. Williams
Treasurer—J. L. Bennett
Recorder—Wm. Ure, M.A.Sc., Ph.D.
Secretary—J. R. Pollock, 4444 West 5th Ave.
Council—Mrs. C. M. Robson; Stanley Burke; N. H. Hawkins; J. A. Mackenzie; C. A. Macdonald; M. A. McGrathe; A. Outram; H. A. Pitman; S. A. Richmond; Rev. C. H. Shortt; G. M. Shrum, M.A., Ph.D.

EDMONTON CENTRE

President—Prof. E. S. Keeping
Vice-President—M. J. Hilton
Secretary—Miss Frances M. Fisher, 10953-123 St.
Treasurer—Dr. E. H. Gowan
Council—Mrs. J. G. Taylor; Robert Chambers; E. N. Higinbotham; Harold Poole Dr. J. W. Campbell.

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

This Society was incorporated in 1890 under the name of The Astronomical and Physical Society of Toronto, and assumed its present name in 1903.

The Society has active Centres in Montreal, P.Q.; Ottawa, Toronto, Hamilton, and London, Ont.; Winnipeg, Man.; Edmonton, Alta.; Vancouver and Victoria, B.C.

The Society publishes a monthly JOURNAL containing each year about 500 pages and a yearly OBSERVER'S HANDBOOK of about 80 pages. Single copies of JOURNAL or HANDBOOK are 25 cents.

Membership is open to anyone interested in astronomy. Annual dues, $2.00; life membership, $25.00. Publications are free to members, or may be subscribed for separately. Apply to the General Secretary, 198 College St., Toronto, or to the local secretary of a Centre.

Extract from the By-Laws: Candidates who are elected to membership will be attached to a particular Centre, or to a section known as *Members at Large*. Members of the Society who live outside of Canada, or in a province in which there is no Centre of the Society will be considered *Members at Large* and not attached to any particular Centre, unless these members are expressly nominated for membership and attachment to a particular Centre. Members may be transferred from one Centre to another, or to the section *Members at Large* by the Council of the Society if written application for such transfer is made by such member to the Council.

The Society has for Sale:

General Index to the TRANSACTIONS of the R.A.S.C., 1890-1905, and the JOURNAL, Vols. 1 to 25, 1907-31.

Compiled by W. E. Harper, Assistant Director, Dominion Astrophysical Observatory, Victoria, B.C.

Pages, 122; Price, $1.00, postage 5c. extra.

New Materials for the History of Man—The Festival of the Dead, by R. G. Haliburton.

This is a research into the Year of the Pleiades, first published at Halifax N.S., in 1863; reprinted by the R.A.S.C. in 1920.

Pages, 126; Price, $1.00, postage 5c. extra.

Send Money Order to 198 College St., Toronto.